

# Changes in TAGH counter coordinates and energies due to Fall 2016 survey

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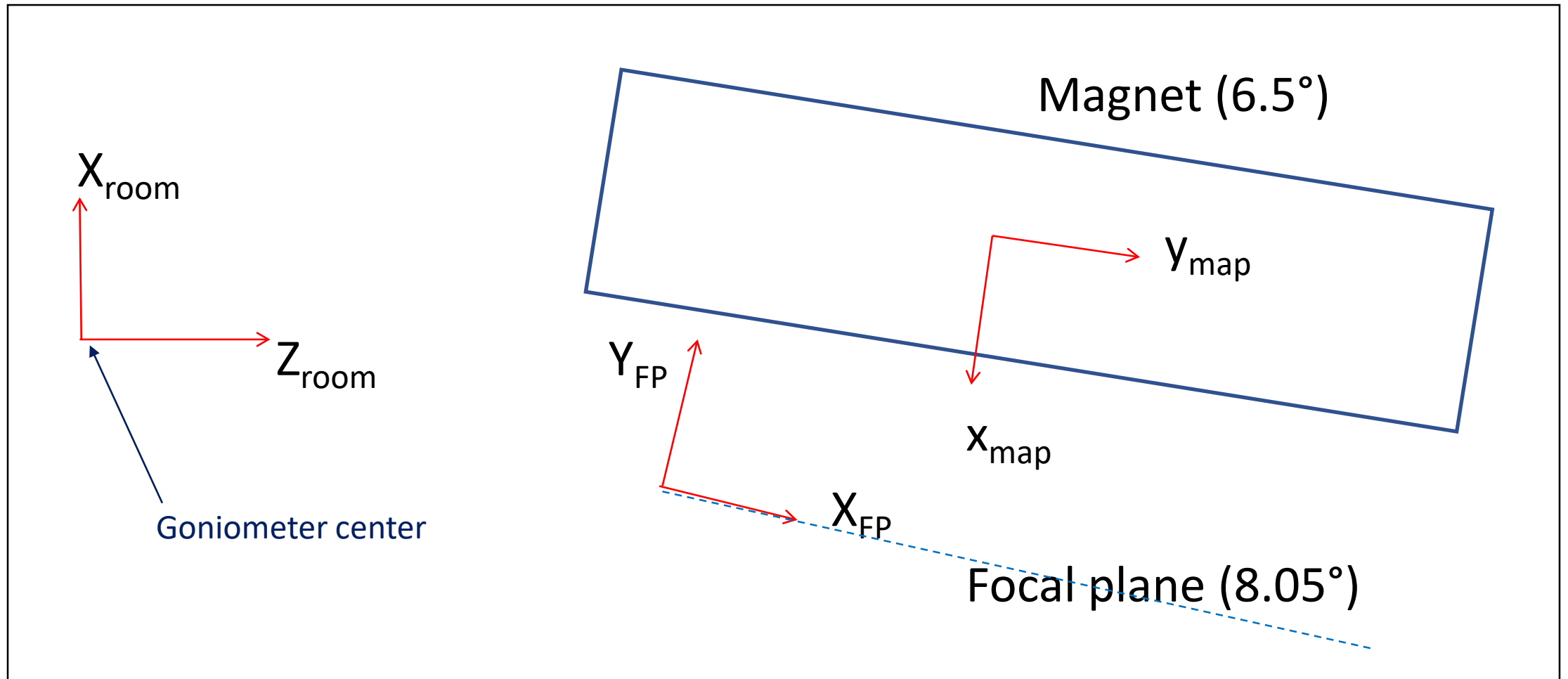
24-Jan-2017

On 11/28/16, Tim Whitlatch sent results of new survey of various beamline components (relative to accelerator and goniometer)

Fall 2016 survey rel to goni foil		MACHINE COORDINATE(M)			DELTA ANGLE (DEG)		
		Z	X	Y	YAW	PITCH	ROLL
HODOSCOPE PLT1 US BR TOP	HODPL1	3.98581	-0.8821	0.06997	-8.045	-0.0071	-0.0114
HODOSCOPE PLT2 US BR TOP	HODPL2	5.27506	-1.0633	0.07006	-8.05	-0.004	-0.213
HODOSCOPE PLT3 US BR TOP	HODPL3	6.55608	-1.246	0.07044	-8.1141	0.02786	0.09826
HODOSCOPE PLT4 US BR TOP	HODPL4	7.54586	-1.3858	0.07037	-8.0036	-0.0225	-0.1508
HODOSCOPE PLT5 US BR TOP	HODPL5	8.59052	-1.5325	0.07017	-8.1125	0.00278	-0.2345
HODOSCOPE PLT6 US BR TOP	HODPL6	9.78627	-1.7007	0.06919	-8.0937	0.03328	-0.2676
HODOSCOPE PLT7 US BR TOP	HODPL7	11.0293	-1.878	0.07017	-8.061	-0.0104	-0.0038
HODOSCOPE PLT8 US BR TOP	HODPL8	12.4509	-2.0741	0.0701	-8.0436	-0.0161	-0.1813
TAGGER MICROSCOPE US CENTER	HDMICR	7.40992	-1.1667	2E-05	-8.0505	0.0023	-0.0118
TAGGER HDTAGG		6.27471	-0.2977	-0.0006	-6.5004	0.0034	-0.0009
TAGGER MAGNET - Pole entrance		3.17284					

I have used these data to recalculate the TAGH counter positions, and used the new counter positions to derive a new energy table.

# Reminder of coordinate systems (not to scale)



Since raytracing is done in map coordinates, I define the origin of the Focal Plane coordinate system to be fixed relative to the center of the magnet.

Some facts about the new survey:

1. The surveyed magnet angle is  $-6.05004^\circ$  (compared to nominal  $-6.05^\circ$ ), so I assume no change in angle.
2. The measured “yaw angles” of the plates vary between  $-8.0036^\circ$  and  $-8.1141^\circ$  (compared to nominal  $-8.05^\circ$ ), so these rotations must be taken into account.
3. Relative to the nominal positions, the center of the magnet is displaced by

$$\Delta Z_{\text{room}} = -1.931 \text{ cm}, \quad \Delta X_{\text{room}} = +0.043 \text{ cm}$$

Since the FP shifts with the magnet,  $\Delta Z_{\text{room}}$  has  $\approx$ no effect on raytracing.

The transverse shift  $\Delta X_{\text{room}}$  has a small effect on raytracing, because it affects the point at which electrons enter the field. From the derivatives tables, I estimate the energy shift to be  $\leq 1$  MeV, so I will not consider it further at this point.

For reference, here are the conversions between the 3 coordinate systems, both nominal and after the Fall 2016 survey: (only the shaded boxes have changed)

Usage: Coordinate in column 1 given by constants in same row,  
 e.g.  $x_{FP} = -418.800 + X_{room} * (-\sin 8.05) + Z_{room} * \cos 8.05$

Nominal coordinates:				(Units: cm, degrees)					
	Room			Map			Focal plane		
	const	Xroom	Zroom	const	xmap	ymap	const	xFP	yFP
Xroom	0	1	0	-29.810	$-\cos 6.5$	$-\sin 6.5$	-69.400	$-\sin 8.05$	$\cos 8.05$
Zroom	0	0	1	629.402	$-\sin 6.5$	$\cos 6.5$	415.090	$\cos 8.05$	$\sin 8.05$
xmap	41.632	$-\cos 6.5$	$-\sin 6.5$	0	1	0	63.596	$\sin 1.55$	$-\cos 1.55$
ymap	-628.731	$-\sin 6.5$	$\cos 6.5$	0	0	1	-208.453	$\cos 1.55$	$\sin 1.55$
xFP	-420.718	$-\sin 8.05$	$\cos 8.05$	206.656	$\sin 1.55$	$\cos 1.55$	0	1	0
yFP	10.588	$\cos 8.05$	$\sin 8.05$	69.211	$-\cos 1.55$	$\sin 1.55$	0	0	1
After Fall 2016 survey of magnet center:				(Units: cm, degrees)					
	Room			Map			Focal plane		
	const	Xroom	Zroom	const	xmap	ymap	const	xFP	yFP
Xroom	0	1	0	-29.767	$-\cos 6.5$	$-\sin 6.5$	-69.357	$-\sin 8.05$	$\cos 8.05$
Zroom	0	0	1	627.471	$-\sin 6.5$	$\cos 6.5$	413.159	$\cos 8.05$	$\sin 8.05$
xmap	41.456	$-\cos 6.5$	$-\sin 6.5$	0	1	0	63.596	$\sin 1.55$	$-\cos 1.55$
ymap	-626.807	$-\sin 6.5$	$\cos 6.5$	0	0	1	-208.453	$\cos 1.55$	$\sin 1.55$
xFP	-418.800	$-\sin 8.05$	$\cos 8.05$	206.656	$\sin 1.55$	$\cos 1.55$	0	1	0
yFP	10.816	$\cos 8.05$	$\sin 8.05$	69.211	$-\cos 1.55$	$\sin 1.55$	0	0	1

(Parenthetically)

New survey of **Microscope position (Upstream Center)**

Zroom, Xroom = 7.40992 m, -1.16666 m      Angle = -8.0505°

In new coordinates (including magnet center shift) microscope is at

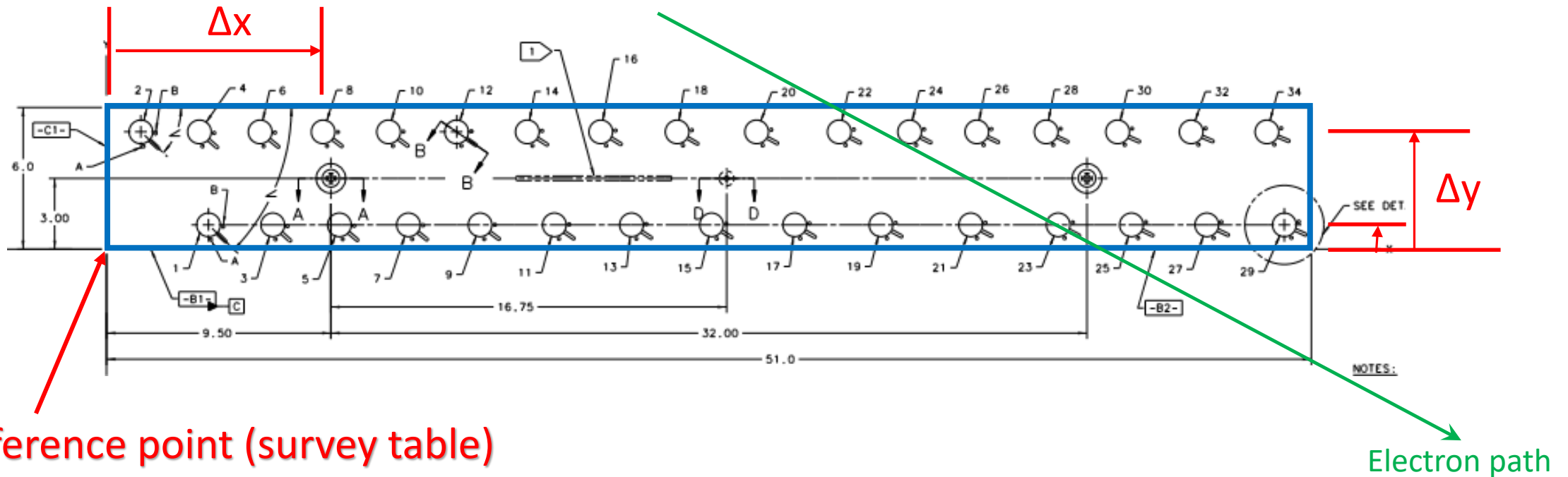
xmap, ymap    =    73.490 cm,    122.629 cm

xFP, yFP       =    331.228 cm,    -0.934 cm

Change in angle is negligible.

# TAGH counter positions

Counter plate 1 (counters 1-30, 32, 34): from Drawing D00001901-203



$\Delta x$  and  $\Delta y$  values come from Bill Crahn's spreadsheet or drawings.

Nominally,  $\Delta y = 1.03150$  inch  $\rightarrow y_{FP} = -18$  cm

$\Delta y = 4.96851$  inch  $\rightarrow y_{FP} = -8$  cm

To calculate positions of counter mounting centers in FP coordinates (relative to magnet center),

1. Calculate position of plate corner in FP coordinates (using survey data for plate corner and magnet center in room coordinates)
2. In FP coordinate system, calculate new position of each counter using tables of  $\Delta x$  and  $\Delta y$  (from Bill Crahn's tables) and change in plate rotation angle (from Fall 2016 survey)
3. Calculate new angle of each counter using Bill Crahn's table corrected by rotation angle of each plate.

With this information, can now generate new tables of counter positions and angles: Counter\_table2017.txt replaces Counter\_table.txt (7/1/2014).

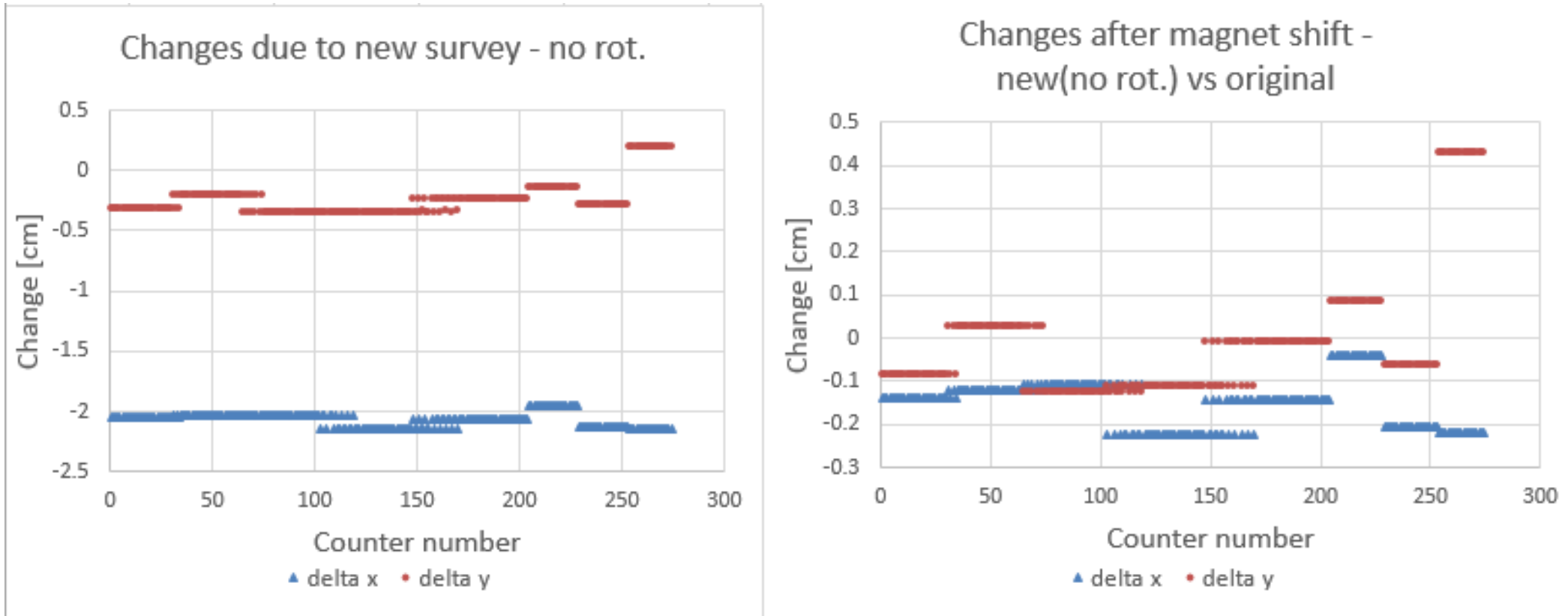
Then, using raytracing tables calculated with SNAKE using final field maps, Interpolate to find new counter energy boundaries (for 0-angle electrons).



Ignoring (for the moment) the rotation of the plates, the shift in counter position is constant on each plate:  $\Delta x$  in blue,  $\Delta y$  in red

Left plot: without magnet shift, right plot: with magnet shift

Except for plate 8, all shifts are < 2.5 mm.

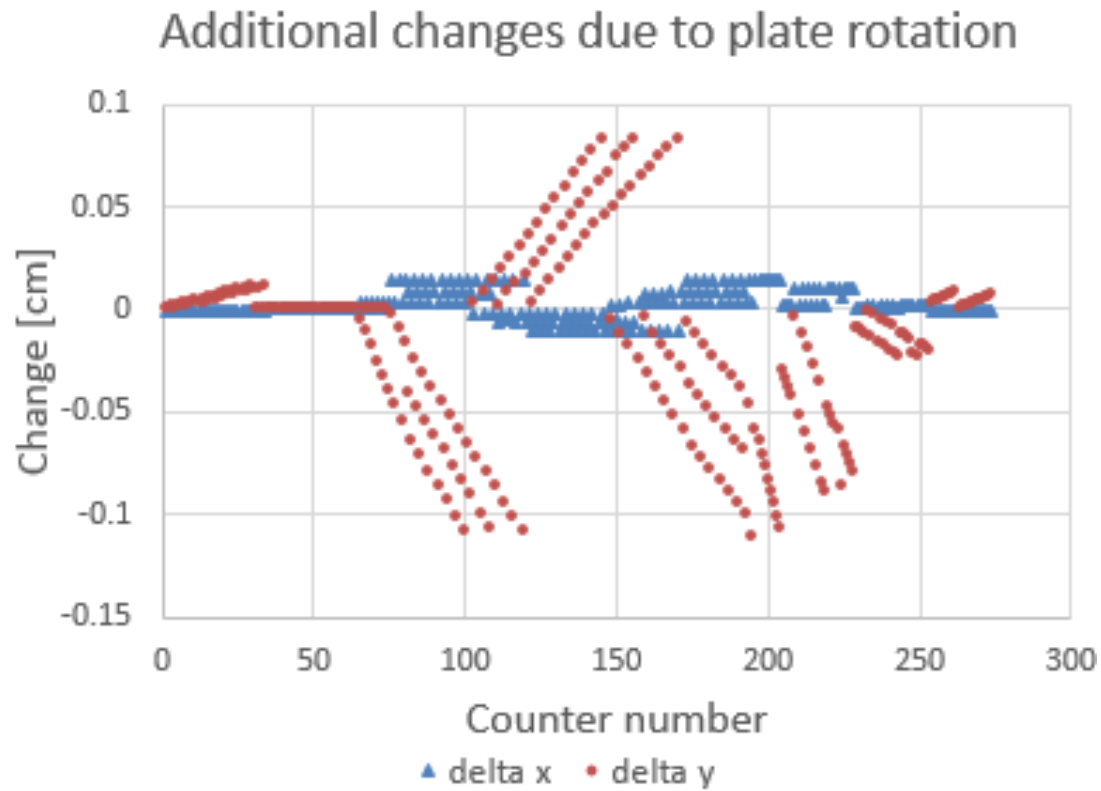


## Summary of changes for each counter plate

Plate	Raw shifts -no rotation		Relative to magnet - no rotation		Change in angle [deg]	Relative to magnet - with rotation			
	dx[cm]	dy[cm]	dx[cm]	dy[cm]		dx[cm]		dy[cm]	
						Min	Max	Min	Max
1	-2.055	-0.313	-0.137	-0.085	0.0050	-0.139	-0.138	-0.085	-0.073
2	-2.039	-0.202	-0.121	0.026	0.0000	-0.121	-0.121	0.026	0.026
3	-2.026	-0.351	-0.108	-0.123	-0.0641	-0.105	-0.094	-0.232	-0.126
4	-2.141	-0.341	-0.223	-0.113	0.0464	-0.234	-0.225	-0.111	-0.030
5	-2.061	-0.236	-0.143	-0.008	-0.0625	-0.140	-0.129	-0.119	-0.011
6	-1.959	-0.143	-0.041	0.085	-0.0437	-0.039	-0.032	-0.005	0.082
7	-2.123	-0.288	-0.205	-0.060	-0.0110	-0.204	-0.202	-0.083	-0.061
8	-2.137	0.202	-0.219	0.430	0.0064	-0.220	-0.219	0.430	0.438

Including plate rotations changes  $\Delta x$  (blue points) negligibly ( $<0.1$  mm),  $\Delta y$  (red points) by  $< 1$  mm:

Note effect of multiple counter planes on Plates 1-6 (especially on 3-6):



# Comparison of new and old counter files

Old (Counter\_table.txt, 7/1/14)

```
#Counter_table2.xlsx          7/1/2014
#Counter table revised to agree with mounting plates (6/30/2014)
#(Nominal energies from Franz's 2013 table on Wiki)
#counter      E?high  E?low  xcenter  ycenter  angle  width
1      11.780  11.770  -0.695  -18.000  44.0776  2.1
2      11.770  11.760  -7.963  -8.000   43.0868  2.1
3      11.760  11.749   6.211  -18.000  42.1164  2.1
4      11.749  11.738  -1.669  -8.000   41.1618  2.1
5      11.738  11.726  13.382  -18.000  40.2374  2.1
6      11.726  11.714   4.859  -8.000   39.3326  2.1
7      11.714  11.701  20.808  -18.000  38.4513  2.1
8      11.701  11.688  11.632  -8.000   37.5929  2.1
9      11.688  11.674  28.506  -18.000  36.7554  2.1
10     11.674  11.660  18.669  -8.000   35.9417  2.1
11     11.660  11.645  36.494  -18.000  35.1487  2.1
12     11.645  11.629  25.982  -8.000   34.3760  2.1
13     11.629  11.613  44.783  -18.000  33.6228  2.1
14     11.613  11.596  33.581  -8.000   32.8880  2.1
15     11.596  11.578  53.389  -18.000  32.1720  2.1
16     11.578  11.560  41.480  -8.000   31.4744  2.1
17     11.560  11.541  62.328  -18.000  30.7931  2.1
18     11.541  11.521  49.695  -8.000   30.1310  2.1
19     11.521  11.500  71.609  -18.000  29.4851  2.1
20     11.500  11.478  58.238  -8.000   28.8547  2.1
21     11.478  11.456  81.116  -18.077  28.2467  2.1
22     11.456  11.433  66.982  -8.078   27.6498  2.1
```

New (Counter\_table2017.txt, 1/24/17)

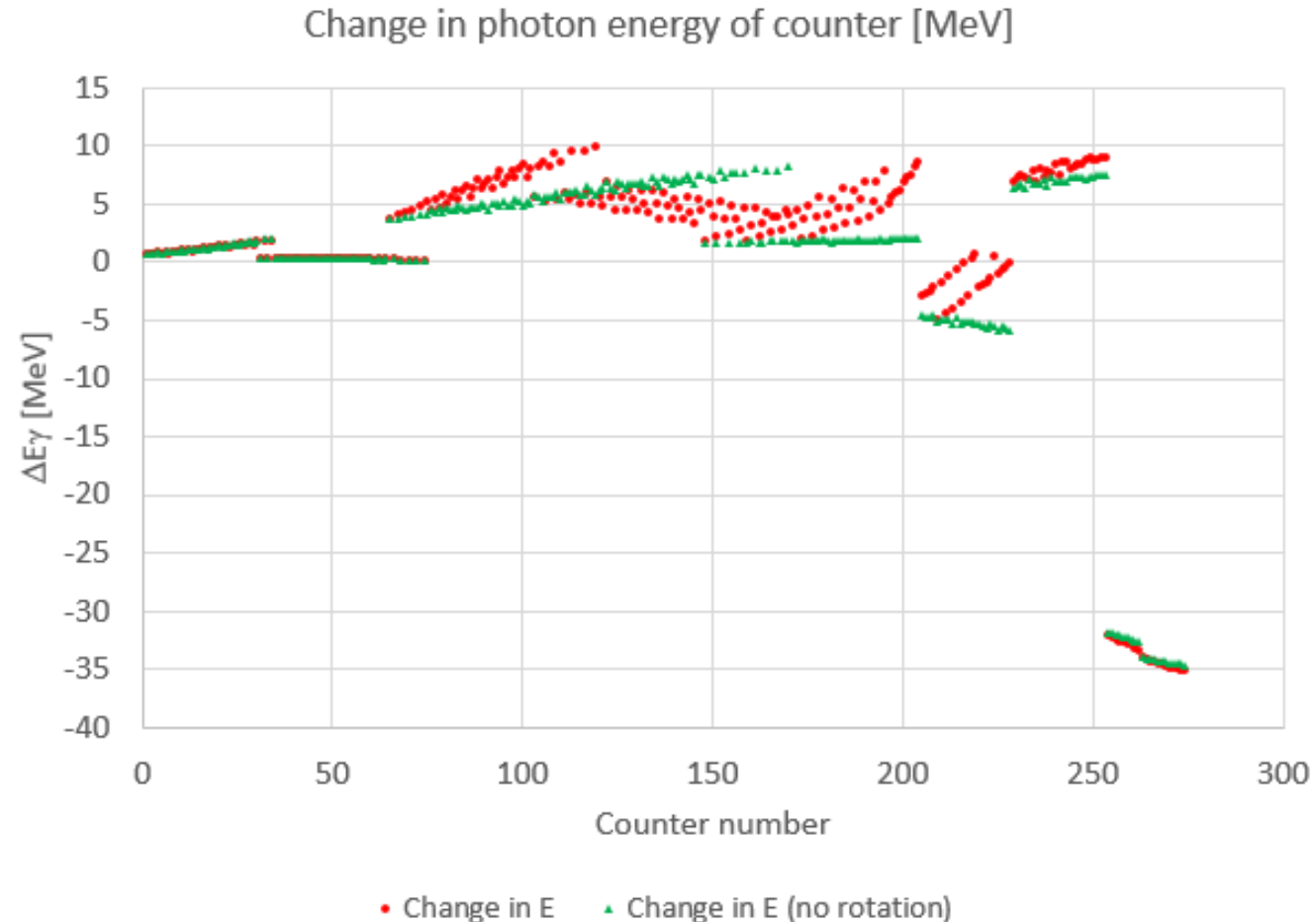
```
#Counter_table2017.txt
#Written 1/24/17 in CounterPlates-work.xlsx
#x, y data from mounting plates (6/30/2014) and Fall 2016 survey, units=cm
#Using magnet shift, plate shift+rotation, and rotation of counter angle
#Neg. counter no. -> omitted in std config.; widths 179-213 revised 7/16
#(Nominal energies from Franz's 2013 table on Wiki)
#Countr Ehigh  Elow  xcenter  ycenter  angle  width
1      11.780  11.770  -0.832  -18.084  44.0826  2.1
2      11.770  11.760  -8.102  -8.085   43.0918  2.1
3      11.760  11.749   6.073  -18.084  42.1214  2.1
4      11.749  11.738  -1.808  -8.084   41.1668  2.1
5      11.738  11.726  13.244  -18.083  40.2424  2.1
6      11.726  11.714   4.720  -8.084   39.3376  2.1
7      11.714  11.701  20.670  -18.082  38.4563  2.1
8      11.701  11.688  11.493  -8.083   37.5979  2.1
9      11.688  11.674  28.368  -18.082  36.7604  2.1
10     11.674  11.660  18.531  -8.082   35.9467  2.1
11     11.660  11.645  36.356  -18.081  35.1537  2.1
12     11.645  11.629  25.844  -8.082   34.3810  2.1
13     11.629  11.613  44.645  -18.080  33.6278  2.1
14     11.613  11.596  33.443  -8.081   32.8930  2.1
15     11.596  11.578  53.251  -18.079  32.1770  2.1
16     11.578  11.560  41.341  -8.080   31.4794  2.1
17     11.560  11.541  62.190  -18.079  30.7981  2.1
18     11.541  11.521  49.556  -8.080   30.1360  2.1
19     11.521  11.500  71.471  -18.078  29.4901  2.1
20     11.500  11.478  58.099  -8.079   28.8597  2.1
21     11.478  11.456  81.116  -18.077  28.2467  2.1
22     11.456  11.433  66.982  -8.078   27.6498  2.1
```

# Results of raytracing (0-angle rays) using new counter position file

Green:  $\Delta E_\gamma$  without plate rotation

Red:  $\Delta E_\gamma$  with plate rotation

Except for Plate 8, differences are less than 10 MeV (compare to channel width 20-30 MeV)



# Have generated new table of energy boundaries and centers for zero-angle electrons (counterbounds2017.out):

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```
Output of counterbounds.f modified 24-Jan-2017
Boundaries of new counter table using July 2015 raytracing
Counter file = Counter_table2017.txt      Ray file = LE+HE.RAYS
Counter numbers with - sign are not installed in standard configuration (signs + widths as of 7/12/16)
Using new rays (Jul 2015) and counters (Jan 2017)
```

ctr	xc[cm]	yc[cm]	wid[cm]	ang[deg]	Ehi[GeV]	Elo[GeV]	ang_high	ang_low	Eav[GeV]	ang_avg
1	-0.832	-18.084	2.100	44.0826	11.77878	11.77001	44.6713	43.7770	11.77439	44.2241
2	-8.102	-8.085	2.100	43.0918	11.76959	11.75934	43.7354	42.7595	11.76446	43.2474
3	6.073	-18.084	2.100	42.1214	11.75853	11.74896	42.6853	41.8312	11.75375	42.2582
4	-1.808	-8.084	2.100	41.1668	11.74847	11.73732	41.7887	40.8543	11.74290	41.3215
5	13.244	-18.083	2.100	40.2424	11.73644	11.72602	40.7830	39.9666	11.73123	40.3748
6	4.720	-8.084	2.100	39.3376	11.72553	11.71339	39.9292	39.0400	11.71946	39.4846
7	20.670	-18.082	2.100	38.4563	11.71244	11.70107	38.9728	38.1961	11.70676	38.5844
8	11.493	-8.083	2.100	37.5979	11.70056	11.68734	38.1623	37.3170	11.69395	37.7396
9	28.368	-18.082	2.100	36.7604	11.68632	11.67393	37.2542	36.5148	11.68013	36.8845
10	18.531	-8.082	2.100	35.9467	11.67337	11.65898	36.4826	35.6794	11.66618	36.0810
11	36.356	-18.081	2.100	35.1537	11.65789	11.64440	35.6209	34.9176	11.65115	35.2692
12	25.844	-8.082	2.100	34.3810	11.64381	11.62817	34.8877	34.1247	11.63599	34.5062
13	44.645	-18.080	2.100	33.6278	11.62701	11.61232	34.0702	33.4014	11.61967	33.7358
14	33.443	-8.081	2.100	32.8930	11.61169	11.59469	33.3734	32.6492	11.60319	33.0113
15	53.251	-18.079	2.100	32.1770	11.59344	11.57748	32.5982	31.9625	11.58546	32.2804
16	41.341	-8.080	2.100	31.4794	11.57682	11.55841	31.9367	31.2482	11.56761	31.5925
17	62.190	-18.079	2.100	30.7981	11.55707	11.53979	31.2000	30.5946	11.54843	30.8973
18	49.556	-8.080	2.100	30.1360	11.53908	11.51915	30.5706	29.9161	11.52912	30.2434
19	71.471	-18.078	2.100	29.4901	11.51773	11.49902	29.8711	29.2949	11.50838	29.5830
20	58.099	-8.079	2.100	28.8597	11.49825	11.47672	29.2720	28.6497	11.48749	28.9608
21	81.116	-18.077	2.100	28.2467	11.47521	11.45497	28.6074	28.0595	11.46509	28.3335
22	66.982	-8.078	2.100	27.6498	11.45416	11.43088	28.0383	27.4482	11.44252	27.7433
23	90.519	-18.076	1.600	27.1351	11.42960	11.41299	27.4167	27.0193	11.42129	27.2180
24	74.541	-8.078	1.600	26.7002	11.41243	11.39355	27.0063	26.5760	11.40299	26.7912

## Summary

- I have calculated TAGH counter positions based on the Fall 2016 survey of the counter plates.
- I have calculated the zero-angle energy boundaries for the counters using the new positions. The shifts are less than  $\approx 1/2$  of a channel width except for Plate 8 (counters 254-274)
- The new counter position table `Counter_table2017.txt` and energy boundary table `counterbounds2017.out` are (or will soon be) posted on my web page <https://userweb.jlab.org/~sober/HallD/> and the GlueX Wiki